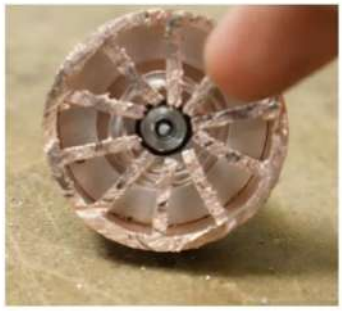
Name: _____ Date: _____

The Magnetron

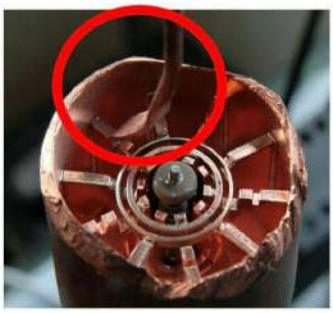
Part I: The Parts of the Magnetron

A magnetron generates microwave radiation. In the pictures below, you can see some structures inside the magnetron, including: (A) a hollow tube running between two strong magnets, (B) a hot wire filament inside the hollow tube with copper "spokes" pointing outward, and (C) a copper antenna attached to the copper spokes. These parts interact to produce microwave radiation that can transfer energy across space.

A. Permanent magnets around a hollow cavity



B. Hot wire filament & copper metal spokes



C. Antenna attached to copper metal spokes

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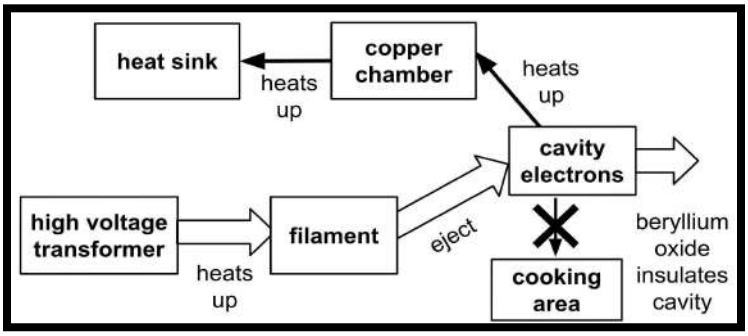
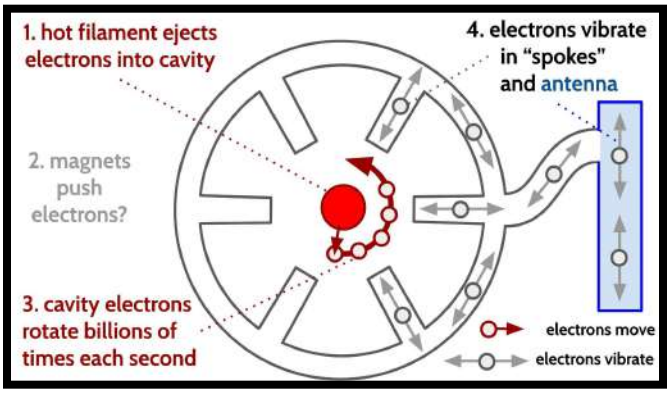
Where have you seen parts or materials with these names before (magnets, copper, antenna, filament)? What have they been used for?

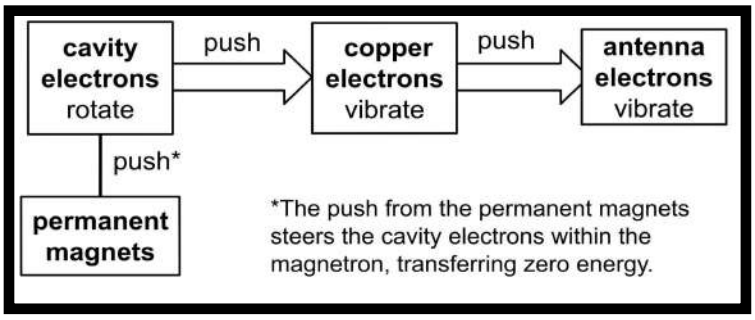
Part II: How the Parts of the Magnetron Interact to Generate Microwave Radiation

When you turn on a microwave oven, a very strong electric current flows from a high-voltage transformer through the metal filament. The filament gets so hot that it ejects electrons, which fly off of it into the empty space in the center cavity. Most microwave ovens have both a small fan to cool off the heat sink attached to the copper chamber around the cavity, and a beryllium oxide insulator to prevent the electrons in the cavity from reaching the cooking area.



The permanent magnets around the cavity apply a force to these flying electrons, pulling them back so they whiz around the center of the cavity in tiny, fast circles. As the electrons move past the "spokes" of the copper structure, they push and pull on the electrons in these spokes, causing those electrons to move in and out through the copper, like an alternating current. The antenna is attached to this copper structure, providing a path for some of this current to flow through. The electrons that flow through the antenna will move back and forth at the same rate as the electrons in the spokes (about 2,450,000,000 times per second, or 2.45 GHz). As the electrons in the magnetron antenna move back and forth quickly, energy moves away from the antenna and through space by transferring energy from the antenna's moving electrons to electric fields.

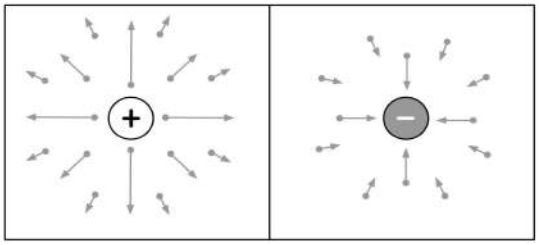




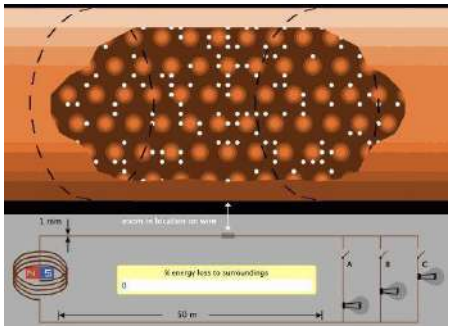
a. What specific task is the magnetron designed to do in order to create microwave radiation?

b. What ideas do you have about how energy is transferred from the magnetron antenna into the food or liquid inside the microwave oven?

Part III: Electric Fields



An **electric field** is the space around a positively or negatively charged particle that will exert force on another charged particle. On a diagram like the one to the right, the arrows show the force that a positively charged particle would feel if placed at each dot. Electric fields are similar to gravitational fields around planets that exert forces on objects that have mass. You may have seen evidence of electric fields in your daily life: when a balloon is rubbed against someone's hair, it can pull the hair outward, even when held at a distance from their head. If you move the balloon back and forth in space, the location of the electric field will change also, so the hair might "follow" the balloon.



You may have previously hooked up light bulbs to a battery to see energy transfer through various paths of metal wire. When copper wire is connected to a battery, the electrons in the wire all start to move at once. The movement of those electrons is due to an electric field in the wire, which pushes electrons to make them move. This electron movement can do things like light up light bulbs, or even broadcast a Wifi signal from an antenna.

a. How do moving charged particles affect electric fields?

b. The energy transfer diagram below does not include electric fields. Where might electric fields cause energy to transfer, either inside or outside the magnetron? Draw it in the diagram.

c. How might the m